REMARKS

Claims 10-57 are pending in this application. By this Amendment, claim 10 is amended. Support for amended claim 10 can be found at least at page 19, lines 7-24; page 32, line 5 - page 33, line 2; page 38, line 10 - page 39, line 8; and Fig. 1. No new matter is added.

Applicants thank the Examiner for the indication that claims 18-41 are objected to as being dependent upon a rejected base claim, but are otherwise allowable.

I. Claim Rejections Under 35 U.S.C. §112

Claim 10 is rejected under 35 U.S.C. §112, second paragraph, as being indefinite. Applicants respectfully traverse the rejection.

The Office Action asserts that the terminology "desired defect region" is vague and indefinite, because the term "desirable" does not limit the parameters of the disclosure to specific percentages. Applicants respectfully disagree with the Office Action.

Growing a single crystal with a desired defect region is known in the art. See V.V. Voronkov, Journal of Crystal Growth, 59 (1982), pages 625-643, recited in the specification at pages 3-4. In this regard, a "desired" defect region refers to an initially-produced defect region, as opposed to an undesired defect region. Therefore, a skilled artisan would readily understand and comprehend the content of the meaning of "desired defect region." Reconsideration and withdrawal are respectfully requested.

II. Rejections Under 35 U.S.C. §103(a)

Claims 10-17 and 42-57 are rejected under 35 U.S.C. §103(a) as being unpatentable over Sakurada et al., U.S. Patent No. 6,482,260 (hereinafter "Sakurada"). Applicants respectfully traverse the rejection.

The claimed invention is directed to "A method for producing a single crystal with pulling the single crystal from a raw material melt in a chamber by Czochralski method,

wherein when growing the single crystal, where a pulling rate is defined as V (mm/min), a temperature gradient of the crystal at the vicinity of solid-liquid interface at a central portion of the crystal is defined as Gc (°C/mm), and a temperature gradient of the crystal at the vicinity of solid-liquid interface at a peripheral portion of the crystal is defined as Ge (°C/mm) during growing a straight body of the single crystal, during pulling the single crystal, the temperature gradient Gc of the crystal at the central portion of the crystal and the temperature gradient Ge of the crystal at the peripheral portion of the crystal are controlled by changing a distance between a melt surface of the raw material melt and a heat insulating member provided in the chamber so as to oppose to the surface of the raw material melt, thereby $\Delta G = |(Gc - Ge)|$ which is difference between the temperature gradient Gc at the central portion of the crystal and the temperature gradient Ge at the peripheral portion of the crystal is 0.5 °C/mm or less, and also V/Gc (mm^2/°C • min) which is a ratio of the pulling rate V and the temperature gradient Gc at the central portion of the crystal is controlled so that a single crystal including a desired defect region is grown." See independent claim 10. Claims 11-17 and 42-57 depend from claim 10. Such a method is not taught or suggested by the cited reference.

According to the claimed invention, in the method of producing a single crystal by Czochralski method, especially, the temperature gradient Gc of the crystal at the central portion of the crystal and the temperature gradient Ge of the crystal at the peripheral portion of the crystal are controlled during pulling the single crystal by changing a distance between a melt surface of the raw material melt and a heat insulating member provided in the chamber so as to oppose to the surface of the raw material melt. At least this feature is not rendered obvious by Sakurada.

For a single crystal including a desired defect region to be produced by the Czochralski method, there is known, for example, a method wherein the single crystal is

pulled with controlling V/G to be a desired value almost constantly. However, in this conventional method, in order to control V/G to be a desired value almost constantly, as the single crystal grows, a pulling rate V has to be changed to a lower rate according to fluctuation (decline) of the temperature gradient G of the crystal. As a result of that, time for growing a straight body of a single crystal lengthens, and thus there is a problem that productivity is lowered. In addition, in the past, the distance between a melt surface of the raw material melt and a heat insulating member has been held constant during pulling the single crystal. Furthermore, the pulling rate of the single crystal is one of the parameters by which a diameter of the grown single crystal is controlled. Therefore, if the aforementioned conventional method is used, a diameter of the single crystal changes. See Specification, page 5, line 2 - page 7, line 22 and page 18, line 17 - page 19, line 6.

However, the present inventors have found that by intentionally changing the distance between the surface of the raw material melt and the heat insulting member during pulling the single crystal, a temperature gradient Gc of the crystal at a central portion of the crystal and a temperature gradient Ge of the crystal at a peripheral portion of the crystal in a direction of pulling axis can be controlled. Furthermore, they have found that by controlling the temperature gradients Gc and Ge of the crystal, difference ΔG between the temperature gradient Gc at the central portion of the crystal and the temperature gradient Ge at the peripheral portion of the crystal during pulling the single crystal can be kept small, and also V/G can be controlled without lowering a pulling rate V during pulling the single crystal. See Specification, page 19, lines 7-24. According to the claimed invention, a single crystal with high quality including a desired defect region over a whole plane in the radial direction entirely in the direction of the crystal growth axis can be produced effectively in a short time and variation of diameters of the single crystal can be reduced. As a result of the claimed method, productivity and yield for producing a single crystal can be improved and

considerable cost reduction can be achieved, and thus the single crystals with very high quality can be provided at low price. See Specification, page 15, line 18 - page 16, line 10 and page 31, line 21 - page 34, line 20.

The Office Action rejects the claims as having been obvious over Sakurada. However, in Sakurada there is no teaching, suggestion or description of changing a distance between a melt surface of the raw material melt and a heat insulating member during pulling the single crystal to control the temperature gradients Gc and Ge. Rather, the single crystal is grown with setting the distance between a melt surface of the raw material melt and a heat insulating member to be constant. Furthermore, Sakurada does not teach controlling V/G.

The object of Sakurada is to provide a method for producing a silicon single crystal wafer and a silicon single crystal wherein OSF region is generated. Yet, except for the OSF region, the region is referred to as an N region in the entire surface of the wafer. See Sakurada, at col. 3, lines 31-38. Specifically, the object of Sakurada is to provide a silicon single crystal wafer wherein the OSF region is generated in an inverted M belt shape and both of the inside and outside of the OSF region are N-region on I-rich side, as illustrated in Figs. 1 and 3, in order that defects detected by Cu decoration are not present. See Sakurada, at col. 3, lines 46-51; col. 7, lines 45-67; and claims 1, 4 and 5.

Moreover, Sakurada discloses a method for producing single crystal in which a crystal pulling apparatus wherein (Ge-Gc) is 0 or a negative value is used so that the OSF region is generated in an inverted M belt shape as illustrated in Fig 1. In the method, the pulling rate of the single crystal is controlled (it is 0.48 - 0.50 mm/min in Fig. 1) so that the single crystal is pulled in the portion of the inverted M belt shape. See Sakurada, at col. 7, line 50 - col. 8, line 14.

For Example, Sakurada teaches a furnace structure wherein a gap 10 between the surface 3 of the silicon melt and the lower end of the annular solid-liquid interface insulator 8

is 70 mm. See Sakurada, at col. 10, lines 28-32. First, slowing down varies the pulling rate of the single crystal. Then, once it is pulled in the portion of the inverted M belt shape, the pulling rate of the single crystal is investigated. Subsequently, as a result of the investigation, a desired single crystal is newly pulled with optimal pulling rate (0.48 - 0.50 mm/min).

In Sakurada, the distance between a melt surface of the raw material melt and a heat insulating member during pulling the single crystal is constant and, unlike the present invention, the distance between a melt surface of the raw material melt and a heat insulating member is not changed during pulling the single crystal. Sakurada does not teach or suggest modifying its disclosed method to include these features, and thus does not teach or suggest all of the limitations of the claimed invention.

As Sakurada does not teach or suggest changing the distance as described above during pulling the single crystal and does not teach or suggest controlling the V/G, claim 10 would not have been rendered obvious by Sakurada. Claims 11-17 and 42-57 depend from claim 10 and, thus, also would not have been rendered obvious by Sakurada. Accordingly, reconsideration and withdrawal of the rejection are respectfully requested.

III. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of the claims are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

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Date: July 30, 2007

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